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NATIONAL DAM SAFETY PROGRAM. POTOMAC RIVER BASIN. LOWER NORTH R--ETC(U)
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POTOMAC RIVER BASIN

Name Of Dam: LOWER NORTH RIVER, NO. 22B

Location: ROCKINGHAM COUNTY, STATE OF VIRGINIA

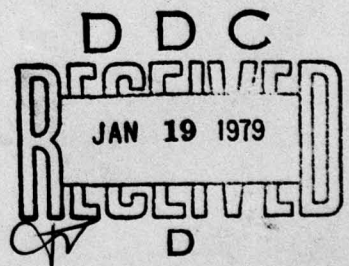
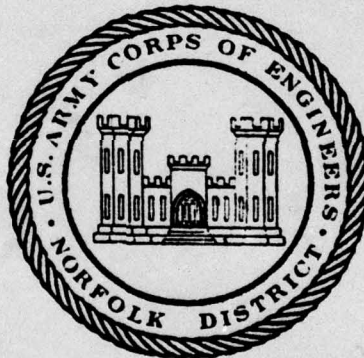
Inventory Number: VA 16504

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PHASE I INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



PREPARED FOR

NORFOLK DISTRICT CORPS OF ENGINEERS
803 FRONT STREET
NORFOLK, VIRGINIA 23510

AUGUST 1978

BY

✓ MICHAEL BAKER, JR., INC.
REAFER, PENNSYLVANIA 15009

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20. Abstract

Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

Based upon the field conditions at the time of the field inspection and all available engineering data, the Phase I report addresses the hydraulic, hydrologic, geologic, geotechnic, and structural aspects of the dam. The engineering techniques employed give a reasonably accurate assessment of the conditions of the dam. It should be realized that certain engineering aspects cannot be fully analyzed during a Phase I inspection. Assessment and remedial measures in the report include the requirements of additional indepth study when necessary.

Phase I reports include project information of the dam and appurtenances, all existing engineering data, operational procedures, hydraulic/hydrologic data, of the watershed, dam stability, visual inspection report and an assessment including required remedial measures.

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

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NAME OF DAM: LOWER NORTH RIVER NO. 22B

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Lower North River No. 22B
State: Virginia
County: Rockingham
Stream: Dry Run, Tributary Within Lower North River Watershed
Date of Inspection: 13 June 1978

BRIEF ASSESSMENT OF DAM

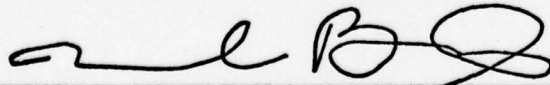
Lower North River Dam No. 22B is an earth dam approximately 74 feet high and 744 feet long, owned and operated by the City of Harrisonburg, Virginia. It was designed by the U.S. Soil Conservation Service as part of the Potomac River Watershed Project. As classified in the Inventory of Dams, this dam is rated as "high" hazard. However, downstream conditions such as the width of the flood plain and small number of inhabitable structures place this dam in the "significant" hazard potential classification.

Within a "significant" hazard classification, the spillway is required to pass the one-half Probable Maximum Flood according to Section 2.1.2 of the Recommended Guidelines for the Safety Inspection of Dams. The dam was designed by the U.S. Soil Conservation Service for a freeboard hydrograph based on 14 inches of rainfall in six hours which approximately equals one-half the Probable Maximum Precipitation. Therefore, the dam will not be overtopped by the one-half Probable Maximum Flood. The other portions of the inspection indicate no serious deficiencies requiring emergency attention. No evidence of unstable slope conditions or seepage on the downstream side was observed.

It is recommended that erosion caused by unauthorized vehicle traffic on the downstream face be repaired as part of the annual maintenance program of the Shenandoah Valley Soil and Water Conservation District. The primary spillway should also be cleared of debris. It is also recommended that additional stability analyses be done using as-built impermeable core dimensions.

Michael Baker, Jr., Inc.

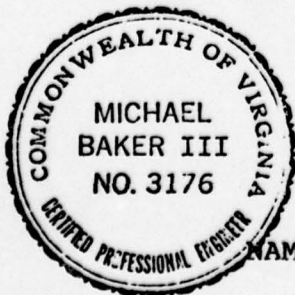
APPROVED:



✓ Michael Baker, III, P.E.
Chairman of the Board and
Chief Executive Officer

Douglas L. Haller
Colonel, Corps of Engineers
District Engineer

Date: _____



NAME OF DAM: LOWER NORTH RIVER NO. 22B

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NAME OF DAM: LOWER NORTH RIVER NO. 22B

OVERALL VIEW OF DAM



OVERALL VIEW OF DAM

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM: LOWER NORTH RIVER NO. 22B ID# VA 16504

SECTION 1 - PROJECT INFORMATION

1.1 General

- 1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to initiate a national program of safety inspections of dams throughout the United States. The Norfolk District has been assigned the responsibility of supervising the inspection of dams in the Commonwealth of Virginia.
- 1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams. The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Description of Project

- 1.2.1 Description of Dam and Appurtenances: Lower North River Dam No. 22B is an earth fill dam with a crest height of 74 feet, a crest length of 744 feet and a crest width of 22 feet. The emergency spillway is an earth and cut bedrock, side channel of trapezoidal shape with a bottom width of 50 feet. The principal spillway is a standard U.S. Soil Conservation Service (S.C.S.) two-way fixed crest concrete riser with a 30 inch reinforced concrete pipe outlet. The reservoir normal pool level is controlled by a fixed orifice with no control gate. A crank operated slide gate has been installed on the upstream side of the riser to drain the lake if necessary. The plan and typical sections of the dam are shown on Plates 1 through 4.
- 1.2.2 Location: Lower North River Dam No. 22B is located on Dry Run about 3000 feet upstream of its confluence with the Dry River as shown on the Location Plan. It is located about 4.5 miles upstream of the Town of Rawley Springs, Virginia in Rockingham County. The dam and reservoir are within the boundaries of the George Washington National Forest.

NAME OF DAM: LOWER NORTH RIVER NO. 22B

- 1.2.3 Size Classification: The dam classifies as an "intermediate" size based upon its height of 74 feet.
- 1.2.4 Hazard Classification: Lower North River Dam No. 22B was given a "significant" hazard classification due to the lack of urban development and the small number of inhabitable structures located downstream from the dam. The hazard classification used to categorize dams is a function of location only and has nothing to do with its stability or probability of failure.
- 1.2.5 Ownership: The dam is owned by the City of Harrisonburg, Rockingham County, Virginia.
- 1.2.6 Purpose of Dam: The purposes of the dam are flood control and water supply.
- 1.2.7 Design and Construction History: The dam was investigated and designed by the S.C.S. from 1965 through 1967 and constructed in 1970 by Hott and Miller. Yearly inspections are made by the S.C.S. Copies of recent inspections are on file at the local S.C.S. office and attached as Appendix V of this report.
- 1.2.8 Normal Operational Procedures: No formal operating procedures are followed on this dam. Normal pool is controlled by the orifice crest at elevation 1968.6 feet. The outflow from this dam combines with flow from an upstream dam to supply water to the City of Harrisonburg. It is not known how often the slide gate drain is operated.

1.3 Pertinent Data

- 1.3.1 Drainage Area: The drainage area of Lower North River Dam No. 22B is 4.03 square miles.
- 1.3.2 Discharge at Dam Site: The maximum known flow at this dam site is unknown. Debris accumulating on the embankment indicates high water has reached an elevation of 1994 feet.

Principal Spillway:

Pool level at emergency	
spillway crest	137 c.f.s.
Pool level at top of dam	147 c.f.s.

Emergency Spillway:

Pool level at top of dam	3913 c.f.s.
------------------------------------	-------------

NAME OF DAM: LOWER NORTH RIVER NO. 22B

1.3.3

Dam and Reservoir Data: Pertinent data on the dam and reservoir are shown in the following table:

TABLE 1.1 DAM AND RESERVOIR DATA

Item	Elevation Feet M.S.L.	Area acres	Reservoir		Length feet
			Acre-	Capacity Watershed inches	
Top of dam	2014.6	29.3	695	3.2	2165
Maximum pool, design surcharge	2010.2	25.1	583	2.7	2005
Emergency spillway crest	2005.8	22.8	473	2.2	1850
Principal spillway crest	1991.8	16.5	215	1.0	1425
Normal pool (a)	1968.6	7.8	40	0.2	685
Streambed at center- line of dam	1943.0	0	0	0	0

(a) Top of conservation pool and bottom of flood control pool measured from orifice crest.

NAME OF DAM: LOWER NORTH RIVER NO. 22B

SECTION 2 - ENGINEERING DATA

2.1 Design: The design data reviewed included the following:

- 1) As-built drawings indicating plans, elevations and sections of the dam and appurtenant structures. Logs of the test borings and test pits were also included in the as-built drawings.
- 2) Hydrologic and hydraulic data.
- 3) Soils and geologic reports (geologic report is presented in Appendix VI).
- 4) Laboratory soil test results.
- 5) Slope stability analyses including the assumed properties of the materials.
- 6) Work plan.
- 7) Seismic survey.

All data has been submitted to the Norfolk District for future reference.

2.2 Construction: The dam was constructed by Hott and Miller in 1970. No construction records were available for this inspection, but records are on file at the S.C.S. in Washington, District of Columbia.

2.3 Operation: The dam is operated and maintained by the Shenandoah Valley Soil and Water Conservation District. Since there are no formal operating procedures for this dam, the slide gate used to drain the reservoir is not periodically operated.

The reservoir level is controlled by an orifice at elevation 1968.6 feet. No records of reservoir levels were available. High water marks indicate the water level has risen to elevation 1994. The outflow from this dam combines with the flow from an upstream dam to supply water to the City of Harrisonburg.

2.4 Evaluation

2.4.1 Design: The stability analyses and as-built drawings do not represent as-built conditions. The as-built impermeable core is larger than considered in the stability analyses. Foundation conditions were determined using the foundation and geologic reports. The hydrologic and hydraulic data provided was adequate for design review.

NAME OF DAM: LOWER NORTH RIVER NO. 22B

- 2.4.2 Construction: Although no construction records were readily available, they are on file at the S.C.S. office in Washington, District of Columbia. Researching the daily quality control and construction progress records, however, is beyond the scope and purpose of a Phase I inspection.
- 2.4.3 Operation: Operational procedures should be improved to include routine opening and closing of the lift gate as part of the annual maintenance program.

NAME OF DAM: LOWER NORTH RIVER NO. 22B

SECTION 3 - VISUAL INSPECTION

3.1 Findings

- 3.1.1 General: The field inspection was made on 13 June 1978. No unusual weather conditions were encountered and the reservoir seemed to be at normal pool. The earth dam and appurtenant structures were found to be in good physical condition. The problems noted during the visual inspection are considered minor and do not require immediate remedial treatment.
- 3.1.2 Dam: Erosion was visible in vehicle tracks which ran straight up the left downstream face of the embankment indicated in Photos 1 and 2. Some railroad ties were placed laterally across the tracks to prevent further erosion and vehicle traffic. Additional railroad ties should be placed on the embankment so that the ruts can be filled in and seeded.

No riprap was placed on the wave berm at normal pool. Although the berm is not eroding, the placement of some riprap and filter cloth would prevent future erosion.

No seepage was found at the downstream embankment slope or at the toe of the embankment.

- 3.1.3 Appurtenant Structures: There was a small amount of debris at the inlet riser which should be cleaned periodically. An alternate riser design should be considered if debris continues to collect at this location.

About seven feet of the stilling basin side-walls' riprap has washed into the basin. Photo 4 is a view of the stilling basin. This old riprap should be removed from the basin and replaced by larger rocks and filter bedding or filter cloth to prevent further erosion.

The approach and discharge channels are used as access roads to get to the top of the dam. The access roads need to be examined periodically to insure that they do not erode.

NAME OF DAM: LOWER NORTH RIVER NO. 22B

- 3.2 Evaluation: None of the items above are serious enough to warrant immediate repairs since they do not threaten the integrity of the dam. However, they should be made a part of the annual maintenance program for this structure.

SECTION 4 - OPERATIONAL PROCEDURES

- 4.1 Procedures: No formal operational procedures are used on Lower North River Dam No. 22B. Normal pool is controlled by the orifice crest at elevation 1968.6 feet. The outflow from this dam combines with flow from an upstream dam to supply water to the City of Harrisonburg.
- 4.2 Maintenance of Dam: The Shenandoah Valley Soil and Water Conservation District conducts annual inspection and maintenance programs for the dam. These programs include representatives from the City of Harrisonburg and the owner of the dam.
- 4.3 Maintenance of Operating Facilities: The lift gate is not opened routinely to see if it is functioning. Fear of debris preventing the closing of the gate was given by the owner as a reason for not routinely checking the gate.
- 4.4 Warning System: At the present time, there is no warning system or evacuation plan in operation.
- 4.5 Evaluation: Maintenance of the operating facilities are considered adequate. However, formal records of lift gate checks similar to the annual inspection reports should be instituted as part of the annual inspections.

NAME OF DAM: LOWER NORTH RIVER NO. 22B

SECTION 5 - HYDRAULIC/HYDROLOGIC DATA

5.1 Design: The elevation of the crest (elevation 1968.6) at the orifice located on the principal spillway inlet tower was established at an elevation which would provide 30 percent of the 100 year conservation storage needed for sediment deposit. The principal spillway crest at elevation 1991.8 was established to provide 90 percent of the 100 year sediment deposit and one inch of flood storage. The capacity (137 c.f.s. with reservoir level at crest of emergency spillway) of the principal spillway was established by consideration of a number of factors including:

- 1) The capability of evacuating the flood storage space within a reasonable time (\pm 10 days).
- 2) Not passing damaging flows down stream.
- 3) The capability of the reservoir to store the flood waters.

The crest (elevation 2005.8) of the emergency spillway was established at the maximum elevation reached in routing the principal spillway hydrograph which resulted from the 50 year, 10 day rainstorm. The elevation of the top of the dam (elevation 2014.6) was established by the maximum elevation reached in passing the freeboard hydrograph. The freeboard hydrograph is that computed from rainfall comparable to approximately 52 percent of the Probable Maximum Precipitation (P.M.P.) as used by the Corps of Engineers and is therefore comparable to one-half the Probable Maximum Flood (P.M.F.). The one-half P.M.F. freeboard hydrograph is developed for a class (b) structure (according to S.C.S. Technical Memo 27). The class (b) designation is comparable to a "significant" hazard classification by the U.S. Army Corps of Engineers.

5.2 Hydrologic Records: No hydrologic records for Lower North River Dam No. 22B were available for Michael Baker, Jr., Inc. inspection.

5.3 Flood Experience: Highwater debris marks on the upstream face of the embankment, shown in Photo 3, indicate that the water level has risen to approximately an elevation of 1994. Based upon the S.C.S. design, the storm would have a 25 year flood or a four percent probability. As referenced previously upon examination of the outlet works, the stilling basin shows signs of erosion caused by large discharges indicated in Photo 4.

NAME OF DAM: LOWER NORTH RIVER NO. 22B

5.4 Flood Potential: Design features of the dam were established by routing various hydrographs as noted in paragraph 5.1.

5.5 Reservoir Regulation: Pertinent dam and reservoir data are shown in Table 1.1, paragraph 1.3.3.

Regulation of flow from the reservoir is automatic. Water rising above the crest of the drop inlet flows into this inlet and through the dam in the 30 inch reinforced concrete conduit. Water also flows past the dam over the ungated emergency spillway in the event water in the reservoir rises over the crest of the spillway.

Outlet discharge capacity, reservoir area and storage capacity, and hydrograph and routing determinations were obtained from reports and computations furnished by the S.C.S. The routing of the emergency spillway and freeboard hydrographs began with the reservoir level at the crest of the orifice (normal pool level, elevation 1968.6).

5.6 Overtopping Potential: The probable rise in the reservoir and other pertinent information on reservoir performance in various hydrographs are shown in the following table:

TABLE 5.1 RESERVOIR PERFORMANCE

Item	Normal	Hydrograph		
		Principal Spillway (a)	Emergency Spillway	Free-Board (b)
Peak flow, c.f.s.				
Inflow	-	-	1977	4426
Outflow	-	137	1342	4060
Peak elev., ft. M.S.L.	1968.6	2005.8	2010.2	2014.6
Emergency spillway				
Depth of flow, ft.	-	0	4.4	8.8
Avg. velocity, f.p.s.	-	0	9.9	13.6
Non-overflow section				
Depth of flow, ft.	-	-	-	0
Avg. velocity, f.p.s.	-	-	-	-
Tailwater elev., ft. M.S.L.	-	-	-	-

(a) 50 year, 10 day volume produces the most conservatively large indication of flood control storage required. Detailed discharge hydrograph was not determined.

(b) One-half P.M.F. by C.O.E. standards.

NAME OF DAM: LOWER NORTH RIVER NO. 22B

- 5.7 Reservoir Emptying Potential: The 30 inch gate on the upstream side of the riser at elevation 1948.5 will permit withdrawal of about 115 c.f.s. with the reservoir at the spillway crest and essentially dewater the reservoir in about eight hours.
- 5.8 Evaluation: Hydrologic and hydraulic determinations of the project as prepared by the S.C.S. appear reasonable. The dam and spillway are designed to pass a flood essentially equal to the one-half P.M.F., which would be developed under standards used by the Corps of Engineers. The project need not pass the P.M.F. because of its "significant" hazard classification.

It should be indicated that conclusions pertain to present day conditions, and that the effect of future development on the hydrology has not been considered.

SECTION 6 - DAM STABILITY

6.1 Foundation and Abutments: The foundation of the dam consists of six to 25 feet of coarse grained alluvium over red sandstone and shale bedrock. The cut-off trench provided for seepage control extends to the unweathered bedrock. Both abutments are composed of red sandstone and shale underlying a shallow residual soil cover. The strike of the bedrock is generally N.35°W. and the dip is 10°E.

6.2 Stability Analysis

6.2.1 Visual Observations: No evidence of instability in the embankment, cut slopes or concrete structures was observed. Minor clear seepage occurs a few feet above the shoreline on the upstream slope of the dam near the left abutment. No other seepage was observed in the embankment, abutments or foundation which would suggest an unstable condition.

6.2.2 Design Data: Slope stability was checked for deep failures by the Swedish Circle Method on a zoned embankment section with a core having slope ratios of three-fourths horizontal to one vertical (0.75:1). The following shear strength parameters were assumed for this analysis:

core $\phi = 25^\circ$, $c = 300$ p.s.f.
shell $\phi = 40^\circ$, $c = 0$
foundation $\phi = 35^\circ$, $c = 0$

The shear strengths of these soils were determined from consolidated undrained triaxial shear tests. A minimum safety factor of 1.35 was computed for the 2.5:1 over 3:1 upstream slope under full drawdown.

The slope stability was not checked by the Swedish Circle Method on the downstream slope. The 2.5:1 downstream slope was assumed to have ample strength as compared to the upstream slope under full drawdown effects. A safety factor of 2.1 was computed using the ratio of the tangents of the ϕ angle to the downstream slope angle.

An analysis by the infinite slope method for a shallow drawdown failure of the upstream slope was also performed. Shear strength of the shell was again evaluated as $\phi = 40^\circ$,

NAME OF DAM: LOWER NORTH RIVER NO. 22B

$c = 0$ and horizontal flow lines were assumed. A safety factor of 1.02 was computed; however, calculations to back up this safety factor were not available.

6.2.3 Operating Records: Recent yearly inspection reports indicate that there are no serious deterioration conditions except for minor erosion. High water marks on the upstream slope indicated in Photo 3 show that the level of the reservoir has risen approximately 25 feet above the normal pool elevation without any significant damage.

6.2.4 Post-Construction Changes: No alterations of the dam since it was constructed were apparent.

6.2.5 Seismic Stability: Lower North River Dam No. 22B is located at the borderline between Seismic Zones 1 and 2 indicating that there is virtually no hazard anticipated from earthquakes according to the Recommended Guidelines for Safety Inspection of Dams. A special seismic survey was conducted for this dam by the S.C.S.

6.3 Evaluation: The stability analysis for the upstream slope is not compatible with as-built conditions. The impermeable core has been constructed with slope ratios of 1.5:1 and not 0.75:1 as shown in the analysis. The as-built flatter core side slopes may cause a larger portion of the failure surface to pass through weaker soil. Therefore, additional stability analyses are recommended using as-built dimensions. Stability analyses by the Swedish Circle Method should also be performed on the downstream slope using the assumed phreatic surface.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

- 7.1 Dam Assessment: The emergency spillway is designed to prevent overtopping of conditions of one-half P.M.F. as consistent with a "significant" hazard classification. The S.C.S. designed the dam with a freeboard hydrograph based on 14 inches of precipitation in six hours. No clear seepage or slope failures were noted that would indicate potential piping or embankment failure. Although some minor erosion exists, major erosion problems are not present.

The data available was sufficient to evaluate the design.

The dam will not require urgent remedial treatment.

- 7.2 Recommended Remedial Measures: Repair of erosion problems as shown in Photos 1 and 2 caused by vehicular traffic on the left downstream face is necessary. The primary spillway should be cleaned and periodically checked in the future. These items can be accomplished through the Shenandoah Valley Soil and Water Conservation District's annual maintenance program or by the City of Harrisonburg. Wave erosion on the upstream slope should be checked yearly to determine if the erosion has progressed to the limit that would require riprap protection. The primary spillway should also be cleaned of debris.

Additional stability analyses are recommended using as-built impermeable core dimensions. The analyses should include a check of the upstream slope under rapid drawdown and the downstream slope under steady state seepage conditions using the Swedish Circle Method.

NAME OF DAM: LOWER NORTH RIVER NO. 22B

APPENDIX I

PLATES

CONTENTS

Location Plan

Plate 1: Plan of Dam and Emergency Spillway

Plate 2: Principal Spillway Excavation and Fill Placement

Plate 3: Profiles and Typical Sections

Plate 4: Riser Details

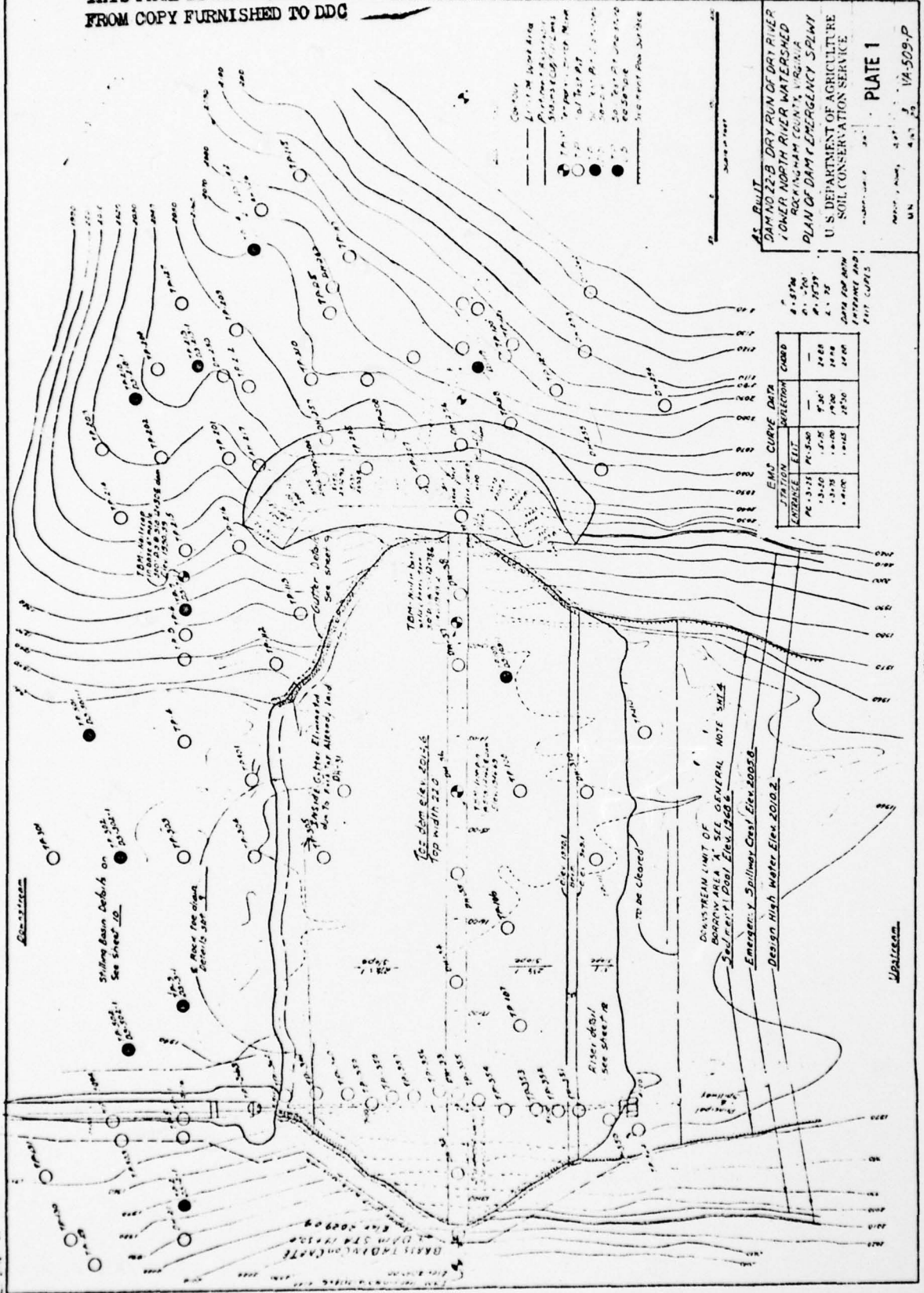
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LOCATION PLAN

LOWER NORTH RIVER No. 22B

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AS BUILT
DAM NO. 22-B DRY RUN OF DRY RIVER
LOWER NORTH RIVER WATERSHED
ROCKINGHAM COUNTY, VIRGINIA
PLAN OF DAM & EMERGENCY SPILLWAY
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

PLATE 1

100' 0" 200' 0" 300' 0" 400' 0" 500' 0" 600' 0" 700' 0" 800' 0" 900' 0" 1000' 0"

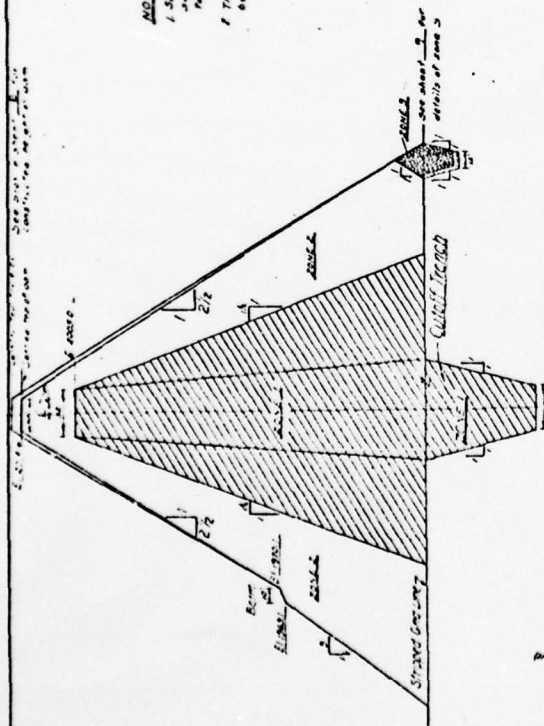
Upstream

NOTES:

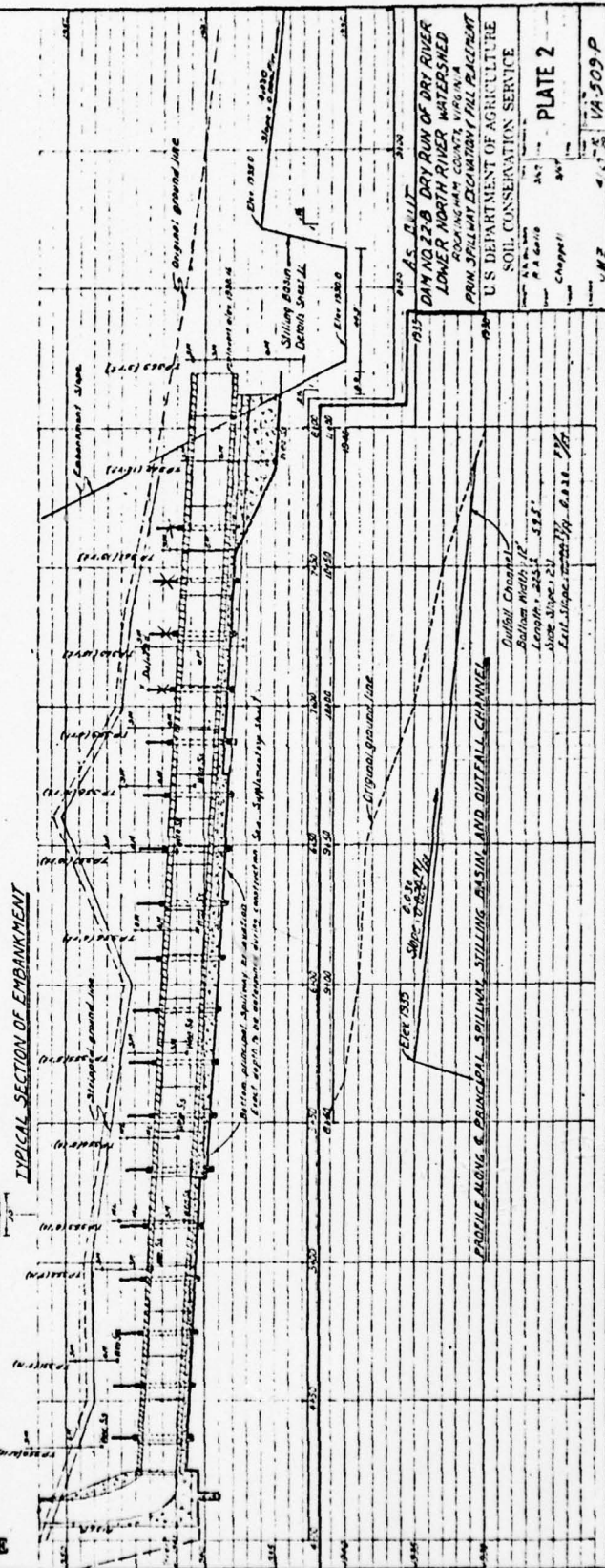
4. Selectively place the most plastic material, such as that represented by T-10 from 42° to 104°, in the downstream portion of swirl reach.

7 The size of the tunnel is approximated and may be adjusted as determined during construction.

3) More hill thickness prior to compaction
4) Few lateral compaction curves per sheet
5) Silty sands to be placed in downstream portion
after fill adjacent to structure, use compaction
may possibly save 3"



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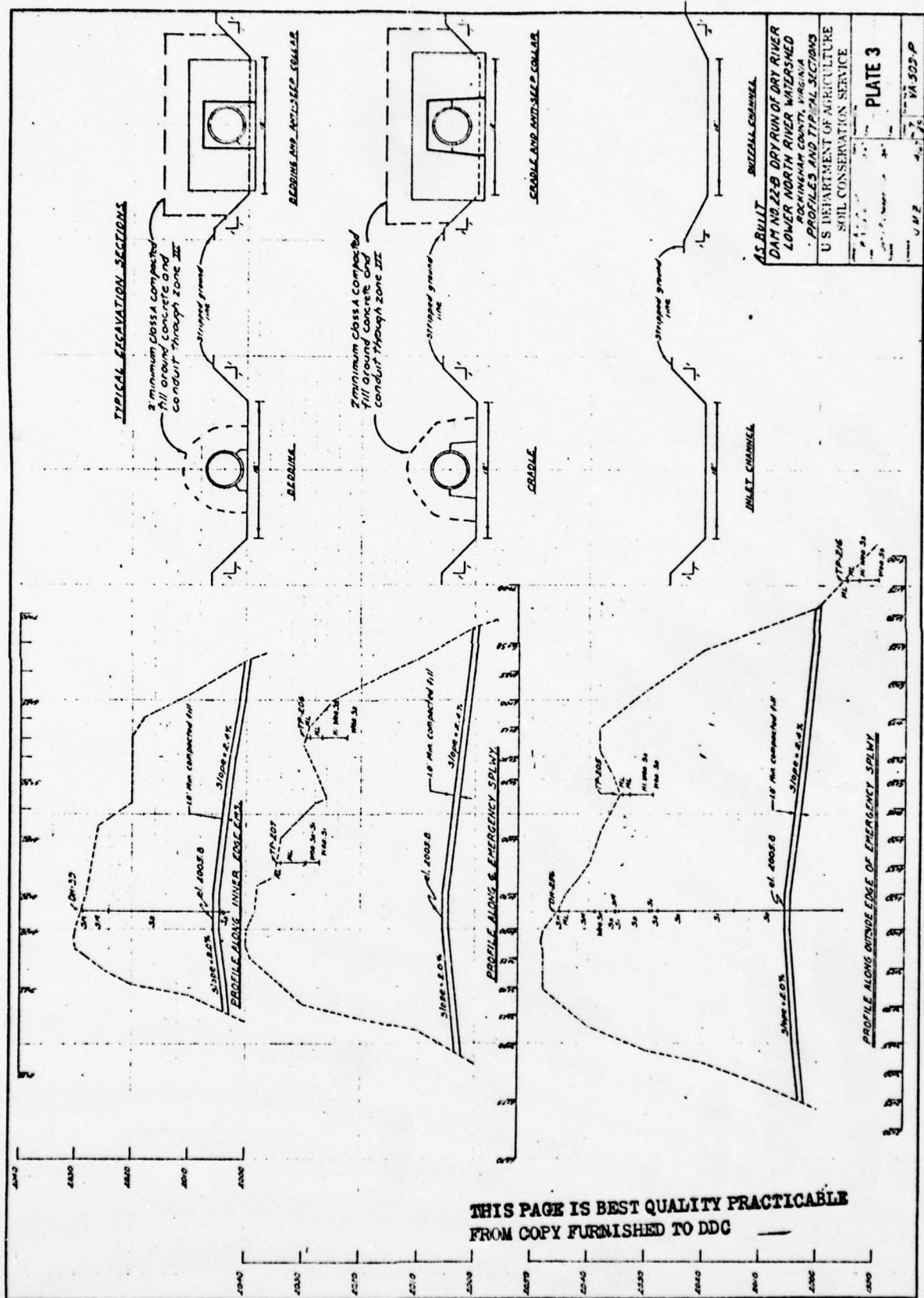


Figure 6-2



APPENDIX II

PHOTOGRAPHS

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- Photo 1: Downstream Slope Showing Vehicle Tracks
- Photo 2: Left Side of Downstream Slope Showing Erosion in Vehicle Tracks
- Photo 3: Upstream Slope Showing High Water Mark and Emergency Spillway
- Photo 4: Principal Spillway Outlet Discharging into Stilling Basin

Note: Photographs were taken 13 June 1978.

NAME OF DAM: LOWER NORTH RIVER NO. 22B



PHOTO 1



PHOTO 2



PHOTO 3



PHOTO 4

APPENDIX III

CHECK LIST - VISUAL INSPECTION

Check List
Visual Inspection
Phase 1

Name Dam Lower North River No. 22B County Rockingham State Virginia Coordinates Lat. N 38°33'33"
Long. E 79°5'45"

Date Inspection 13 June 1978 Weather Partly Cloudy Temperature 79° F.

Pool Elevation at Time of Inspection 1968.8 M.S.L. Tailwater at Time of Inspection 1936.2 M.S.L.

HHH-1

Inspection Personnel:

MICHAEL BAKER, JR., INC.: VIRGINIA WATER CONTROL BOARD:

D. J. Greenwood
J. M. Thompson
W. L. Sheaffer

K. Hinkle

D. J. Greenwood Recorder

EMBANKMENT

Lower North River No. 22B

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	No surface cracks were found during the inspection by Michael Baker, Jr., Inc. of the top, upstream face and downstream face of the embankment.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	There was no unusual movement or cracking found at the time of the Michael Baker, Jr., Inc. inspection.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	The embankment slope was well seeded with little erosion. However, erosion was present where a vehicle had been driving up the embankment on the left side of the downstream face. The city of Harrisonburg has attempted to stop this unauthorized activity by placing unequally spaced logs up the face over the vehicle tracks. No slough was observed.	The City of Harrisonburg should place several more logs to resist erosion and should fill in and reseed these areas.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	The crest alignment of the dam was good with no unusual irregularities or changes in alignment.	
RIPRAP FAILURES	The embankment riprap gutters appear to be working well with very minor erosion apparent in their vicinity. The riprap of boulders and cobbles appears to be adequately sized and shows no sign of movement. The wave berm at normal pool level is not riprapped.	The wave berm may need riprap in the future if erosion becomes a problem.

EMBANKMENT

Lower North River No. 22B

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONSTRUCTION MATERIAL	Damp, silty sand, gravel and rock fragments with a few inches of topsoil were observed to be well compacted on the surface of the dam slopes. The dam was designed to be constructed in two zones of material including an impervious core.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	The junctions are covered with a riprap gutter and thus no erosion or cracking was visible. Both abutments are composed of firm red sandstone, shale and siltstone with horizontal bedding planes and steep joints to form an apparent water tight bond.	
ANY NOTICEABLE SEEPAGE	There is minor clear seepage (less than one g.p.m. over a 10 by 20 feet area) a few feet above the existing shoreline of the upstream slope of the dam near the left abutment which probably originated from hillside and rubble gutter drainage.	
STAFF GAGE AND RECORDER	There is no staff gage or recorder.	
DRAINS	A rock toe drain is present and is tied into the gutter drain at the abutment contacts. This drain appears to be working well as there are no wet areas noticeable downstream from it. The boulders and cobbles vary from 0.5 to 3.0 feet in diameter. The width of the drain varies from 15 to 20 feet.	
FOUNDATION	Red and gray hard fine grained sandstone with some softer siltstone and shale is recorded in the test borings drilled for the dam. There are steep joints and fractures. The bedding planes are horizontal. The strata are in the Hampshire Formation of the Devonian System. There is a cutoff trench. The rock exposed in the spillway cut is similar to that described in the test borings.	

OUTLET WORKS

Lower North River No. 22B

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	The outlet conduit is a 30 inch pipe with concrete bedding. Both the pipe and bedding are in good condition with no cracks or spalling.	Very good condition.
INTAKE STRUCTURE	The concrete intake riser is a two-way fixed crest type with a low water inlet orifice and a drain controlled by a gate and lift. The lift is in good condition and operable. There is a slight amount of debris caught in the trash racks.	The debris on the inlet riser should be cleaned periodically. A check should also be made on alternative trash rack designs if debris continue to collect in the riser.
OUTLET STRUCTURE	The outlet is a 30 inch concrete pipe discharging into a riprapped stilling basin. The riprap in the stilling basin has been washed away in some areas and erosion is present on the basin sides.	The stilling basin should be cleaned and the sides riprapped with a larger rock size to prevent further erosion.
OUTLET CHANNEL	The outlet channel is uniform in shape and in good condition showing that the stilling basin has functioned properly in the past.	
EMERGENCY GATE	The emergency gate is a 30 inch diameter slide gate at elevation 1948.5 and operated by a hand crank pedestal. No signs of rust were present.	The gate should be operated periodically.

UNGATED SPILLWAY

Lower North River No. 22B

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
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CONCRETE WEIR

There is none.

APPROACH CHANNEL

The emergency spillway approach channel is at an adverse slope of two percent. The approach channel appears to be bedrock covered with topsoil and a very good, heavy growth of ground cover. The center of the approach channel is used as roadway to the upstream side of the dam.

Periodic examination of the roadway is necessary to check for erosion.

DISCHARGE CHANNEL

The emergency spillway discharge channel is at a 2.4 percent positive slope. The channel appears to be bedrock covered with a thin compacted earthfill and a very good heavy growth of ground cover. Riprap is placed in critical erosion areas downstream. The center of the approach channel is used as a roadway for access to the dam.

BRIDGE AND PIERS

There are none.

CUT SLOPES

Red and gray hard sandstone with interbedded medium hard siltstone and soft shale were observed in the cut slopes. The bedding planes are horizontal. There are two sets of steep to vertical joint systems, the cut slopes on both sides were made of a 1:1 ratio and appear to be stable with minor amounts of small rock talus.

INSTRUMENTATION

Lower North River No. 22B

<u>VISUAL EXAMINATION</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
MONUMENTATION/SURVEYS	None were noted.	
OBSERVATION WELLS	There are none.	
WEIRS	There are none.	
PIEZOMETERS	There are none.	
OTHER	There are none.	

RESERVOIR

Lower North River No. 22B

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
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SLOPES

The reservoir slopes appear to be stable and well vegetated with little erosion. There was no unusual slope movement detected. The slopes are on undeveloped U.S. Forest Service Land.

SEDIMENTATION

Unusual sedimentation upstream of the dam was not noticeable. No detailed sedimentation studies have been initiated to date.

DOWNSTREAM CHANNEL

Lower North River No. 22B

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
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CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The downstream channel is primarily comprised of small rocks with earth sides. There was no unusual debris built up in the channel.	
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SLOPES	The downstream slopes of Dry Run start at about 200 feet on each side of the channel and rise very rapidly to the mountain tops. Dry Run flows into the Dry River which has a much larger flood plain approximately 600 feet wide between the slopes which rise rapidly to the mountain tops. The stream channel slope is about three percent at dam.	
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APPROXIMATE NO. OF HOMES AND POPULATION	Approximately 50 structures are located downstream primarily in the Town of Rawley Springs (adjacent to Dry River, with an estimated population of 100). The City of Bridgewater is located approximately 15 miles downstream with a population of 2828.	
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APPENDIX IV

CHECK LIST - ENGINEERING DATA

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 4.0 square miles, heavily forested,
undeveloped, steep slopes

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1968.6 (40 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 2005.8 (570 acre-feet)

ELEVATION MAXIMUM DESIGN POOL: 2010.2 (680 acre-feet)

ELEVATION TOP DAM: 2014.6 (791 acre-feet)

CREST: Emergency spillway - earth and rock

- a. Elevation 2005.8
- b. Type Trapezoidal earth and rock channel
- c. Width 50 feet bottom and 3:1 and 5:1 side slopes
- d. Length 380 feet
- e. Location Spillover Located over right abutment
- f. Number and Type of Gates No gates, uncontrolled spillway

OUTLET WORKS: Principal spillway - concrete riser and outlet pipe

- a. Type Standard fixed crest S.C.S. concrete riser
- b. Location Left upstream side of dam
- c. Entrance inverts 1991.8 (fixed crest), 1968.6 (orifice crest--normal pool)
- d. Exit inverts 1938.16
- e. Emergency draindown facilities Elev. 1948.5 - 30 inch diameter gate

HYDROMETEOROLOGICAL GAGES: None located at dam

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE Unknown

Dam Name: Lower North River No. 22B

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Lower North River No. 22B

ITEM	REMARKS
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PLAN OF DAM	A complete set of as-built plans are available at the Norfolk District of the Corps of Engineers. Plan view of the dam is included in this report as Plate 1.
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REGIONAL VICINITY MAP	The cover sheet for the S.C.S. design drawings was used as a vicinity map and is attached as the Location Plan.
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CONSTRUCTION HISTORY	The foundation investigation was done in 1965. The dam was designed by the S.C.S. in 1970 and constructed by Hott and Miller in the same year.
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TYPICAL SECTIONS OF DAM	Typical sections of the dam are enclosed in the Phase I Construction Report as Plate 2.
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HYDROLOGIC/HYDRAULIC DATA	A complete set of hydrologic and hydraulic data is available at the Norfolk District of the Corps of Engineers.
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OUTLETS - PLAN and	
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- DETAILS	are available at the Norfolk District
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- CONSTRAINTS and	
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- DISCHARGE RATINGS	are included in the S.C.S. design calculations and are available at the Norfolk District
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RAINFALL/RESERVOIR RECORDS	No rainfall or reservoir level records are available at the dam. Rainfall data is available from Virginia Climatological Records.
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Lower North River No. 22B

ITEM	REMARKS
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DESIGN REPORTS	Design calculations by the S.C.S. are available at the Norfolk District; Contract specifications are not available.
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GEOLOGY REPORTS	A subsurface investigation consisting of test pits and test borings are part of the design documents. Formal geology reports are not available.
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DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Design computations were done by the S.C.S. for hydrology and hydraulics. Stability on seepage calculations are not available.
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IV-2

MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	A foundation and borrow investigation was performed with test borings and test pits. Constant head borehole permeability tests and pressure testing with packers were done in the borings.
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POST-CONSTRUCTION SURVEYS OF DAM	The dam is inspected yearly by the S.C.S. District Conservationist. Copies of these inspection reports are attached to this report.
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BORROW SOURCES	Seven borrow areas were used for embankment materials. One borrow area was located above the right abutment. The other six borrow areas were upstream of the sediment pool elevation.
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Lower North River No. 228

ITEM	REMARKS
MONITORING SYSTEMS	No monitoring systems other than the spillway riser were designed into the dam.
MODIFICATIONS	No known modifications have been made other than repairing erosion and reseeding.
HIGH POOL RECORDS	No high water records are available.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Yearly inspections are made by the District Conservationist of the S.C.S. No known major construction has been done since the dam was built.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE OPERATION RECORDS	None, except the S.C.S. and City of Harrisonburg have plans to reseed areas of the dam and perform maintenance items. The list will be sent to Michael Baker, Jr., Inc. by the S.C.S.

Lower North River No. 22B

ITEM	REMARKS
SPILLWAY PLAN	Sections and details of the ungated bedrock and earthen overflow spillway are enclosed as Plate 3.
SECTIONS	The section measured in field closely matches that on the plans, i.e., 50 feet wide and approximately the same slopes in rock and earth with minimal growth. Slight erosion was noted from hillside drainage.
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	Crank operated lift with pedestal base was used. Plans and details are available at the S.C.S. Richmond Office.

APPENDIX V

ANNUAL MAINTENANCE INSPECTION REPORTS

S... JOAH VALLEY SOIL AND WATER CONSERVATION DISTRICT
Report of Annual Maintenance Inspection of Watershed Dams in
LOWER NORTH RIVER WATERSHED PROGRAM

April 12, 1978

An inspection was made on 5 dam sites in Lower North River Watershed.
Those present on the inspection were:

Gerald Fawley	Chairman District Board
James Moyers	Chairman Watershed Committee
Arlis Frymyer	District Director
John Crist	Soil and Water Conservation Commission
Don Parslow	U.S. Forest Service
Randy Maupin	Soil Conservation Service

The following observations were made by members of the inspection party.

<u>Site No.</u>	<u>Date Completed</u>	<u>Date of last Inspection</u>	<u>Remarks</u>
22 B	4-67	4-23-77	Additional rail or large stone needed to control traffic in borrow area above spillway where new guard rails were placed. Work reported needed in Borrow Area C has not been completed.
81 C	10-75	-	Site in good condition. Suggest top of dam be fertilized at regular intervals to maintain grass stands.
80	3-67	4-20-77	Repairs needed on path that has been worn to waters edge on wet side of dam.
83	4-65	4-20-77	Vehicle traffic has worn off vegetation in several areas. No repair needed at this time.
78	11-65	4-20-77	Trash rack needs repair. Bolts broken that hold steel bars in place. Vegetation has been worn off by vehicle traffic in several areas but repairs not suggested at this time.

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SHENANDOAH VALLEY SOIL AND WATER CONSERVATION DISTRICT
REPORT OF ANNUAL MAINTENANCE INSPECTION OF WATERSHED DAMS IN

LOWER NORTH RIVER WATERSHED PROGRAM

May 28, 1976

On May 28, 1976 E. B. Craun, Shenandoah Valley Soil and Water Conservation District Director; Don Parslow, U. S. Forest Service; and Randy Maupin, District Conservationist Soil Conservation Service, made an annual maintenance inspection of the completed flood control structures in Rockingham County, Virginia.

The following observations were made by the members present on the inspection team:

- Dam No. 78 -- Area between highway and lake has a steep bank that is sloughing off of approximately 1,000 square feet. It should be overseeded with a mixture of fescue and sercia lespedeza plus fertilizer.
- Dam No. 83 -- Upper borrow area shows evidence of sheet erosion. Suggest that overseeding be done over the approximate 2 acres with a mixture of fescue and sercia lespedeza. Gully on south side of road at second waterbreak up stream from spillways. Forest service will take care of this problem.
- Dam No. 80 -- On dry side of dam traffic is apparently stopped and it is felt that it will revegetate naturally. Foot path on wet side of dam near center is still getting traffic and will need further study to determine remedy.
- Dam No. 22B -- Borrow area no. C has break in diversion also about $\frac{1}{4}$ acre bare of vegetation. This area needs attention as soon as possible. On dry side of dam jeep trail is still being used. Gate has not been installed, therefore, need to inquire as to status from city of Harrisonburg.

This report is concurred by:

E. B. Craun
E. B. Craun, Shenandoah Valley Soil and Water
Conservation District Director

Randolph J. Maupin
Randolph J. Maupin, District Conservationist, Soil
Conservation Service

Don Parslow
Don Parslow, United States Forest Service

DISTR: State Ofc.
Area Office
Rockingham Ofc.
U.S. Forest Service
Shenandoah Valley SWCD
City of Harrisonburg

Page 2, Part of Annual Maintenance Inspection
of Watershed Dams in Lower North River
Watershed Program

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<u>Site No.</u>	<u>Date Completed</u>	<u>Date of last Inspection</u>	<u>Remarks</u>
22 B	4-67	5-28-76	Vehicle traffic on the dry side of Dam has worn away vegetation. Vehicle traffic into borrow area east of the spillway has created two small gullies approximately 200 feet long. Traffic control and seeding needed. Borrow area C above the lake site has a break in berm and some bare areas above and below. 1/3 acres of revegetation needed.

Mr. Locker agreed that the City of Harrisonburg will assist the District with making the necessary repairs on this site.

This report is concurred by:

Carl S. Lively, Shenandoah Valley Soil and Water Conservation District

Gerald E. Fawley, Shenandoah Valley Soil and Water Conservation District

Harold H. Bush, Shenandoah Valley Soil and Water Conservation District

Don Parslow, United States Forest Service

Randolph J. Maupin, District Conservationist, Soil Conservation Service

Edward Loker, City of Harrisonburg

SHENANDOAH VALLEY SOIL AND WATER CONSERVATION DISTRICT

Report of Annual Maintenance Inspection of Watershed Dams in

LOWER NORTH RIVER WATERSHED PROGRAM

April 20 and 23, 1977

On April 20, 1977 Carl Lively and Gerald Fawley, District Directors, and Randy Maupin, District Conservationist, Soil Conservation Service, made an annual maintenance inspection of Dam Sites #78, Briery Branch, #83, Hone Quarry, and #80, Union Springs. Don Parslow of the U.S. Forest Service was called on a forest fire and was unable to make the inspection tour with the group, but had visited site #78 and #80 recently.

The following observations were made by members of the inspection team:

April 20, 1977

<u>Site No.</u>	<u>Date Completed</u>	<u>Date of last Inspection</u>	<u>Remarks</u>
78	11-65	5-28-76	Area sited as needing seeding in last years report in stabilizing. Vehicle traffic is creating damage to outer slope of spillway. Seeding not needed at this time but control of traffic needed. Few large logs on wet slope of Dam should be removed.
83	4-65	5-28-76	Vehicle traffic on steep slopes in borrow area needs control. Few large logs on wet slope of Dam need removal.
80	3-67	5-28-76	Traffic near the center on the wet side of the Dam is continuing. Vegetation is being worn away. This is not a hazard to the structure at this time.

April 23, 1977

Dam #22 B was inspected by Harold H. Bush, District Director, Ed Locker, City of Harrisonburg, Don Parslow, U.S. Forest Service, and Randy Maupin, District Conservationist, Soil Conservation Service.

APPENDIX VI

GEOLOGIC REPORTS

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DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

GENERAL

State Virginia County Rockingham; — $\frac{1}{4}$, — $\frac{1}{4}$, Sec. —, T. — R. —; Watershed Lower N. River
 Subwatershed Dry Run Fund class FP Site number 22B Site group 1 Structure class b
 (FP-2, WP-1, etc.)
 Investigated by T. Mack, Geologist Equipment used International TD 6 tractor w/walk-roy backhoe - Sprague & SITE DATA Henwood drill - International TD 9 dozer. Date 3/66
 (Type, size, make, model, etc.)
 Drainage area size 4.03 sq. mi., 2579.2 acres. Type of structure Earthfill Purpose Flood Prevention
 Direction of valley trend (downstream) N.E. Maximum height of fill 59.0 feet. Length of fill 730
 Estimated volume of compacted fill required 238,708 yards

STORAGE ALLOCATION

	Volume (ac. ft.)	Surface Area (acres)	Depth at Dam (feet)
Sediment	<u>100</u>	<u>5.5</u>	<u>12</u>
Floodwater	<u>473</u>	<u>21.2</u>	<u>50</u>

SURFACE GEOLOGY AND PHYSIOGRAPHY

Physiographic description Ridge & Valley Topography Mountainous Attitude of beds: Dip 10° E Strike N 35° W
 Steepness of abutments: Left 42 percent; Right 42 percent. Width of floodplain at centerline of dam 470 ft

General geology of site: Lower North River Site #22B is located in western Rockingham County in the George Washington National Forest. The site is on Dry Run, which is a tributary of Lower North River. Dry Run enters Lower North River 700 yards below the dam site.

Lower North River Site #22B is underlain by the Hampshire formation which is of upper Devonian age. The Hampshire formation here occurs in a gentle anticlinal (upturned) fold. The dips in this anticline, the Bergton-Crab Run anticline (Brent, 1960) do not exceed 10° in this area. In this fold fracturing is more pronounced than normal. The fractures in an anticlinal fold are generally tension fractures. Tension fractures are more open than compression fractures. Compression fractures occur in synclinal folds. Synclines are more common in the Appalachian region than anticlines.

The Hampshire formation here is hard, tightly indurated, fine

VA-509-G

grained, massive, solid, red sandstone interbedded with moderately soft red siltstone. The siltstone forms approximately 5 percent of the formation. The rock is fractured to highly fractured and jointed. The fracture pattern is generally vertical and horizontal fractures. These form 90 degree joints in the sandstone and generally more acute angle joints in the siltstone.

Dry Run flows in a strongly entrenched dendritic pattern between steep valley walls. The stream is degrading. This degrading action is now in the process of flushing out the fines that are present in the cobbles and boulders in the stream valley. These boulders and cobbles are red and gray hard sandstone. This material is also present on high terraces such as the bench underlying part of the emergency spillway area. Little colluvium is present.

Methods and Procedures

1. The dam site was moved 300 feet upstream. This was done because of the fractured rock that was found to occur in the left abutment on the first site. Water was lost here. This water passed through the abutment and flowed out into the Lower North River stream valley. The path of this flow appeared critical. This would indicate that the abutments on the first site are incapable of holding water.
2. Standard equipment was used for penetration resistance tests.
3. Types of permeability testing were described in the section entitled "Note" in the logs. Also given is the method of calculating the permeability factor.
4. Soil to be used as borrow material is classified by the Unified Soil Classification. For correlation to samples, this soil is also classified by the USDA Soil Classification System.
5. Dry weather was present during both backhoe and drilling operations.

Centerline of the Dam

The centerline of the dam is placed on a stream valley that has fairly deep, coarse-grained alluvium present. This stream valley is between two steep abutments. Shallow residual soil occurs on these abutments.

Red sandstone and shale underlie the centerline of the dam. This rock is weathered and fractured on the abutments to a depth of approximately 25 to 30 feet from the top of the ground. In the flood plain the rock is considerably less fractured. The greater degree of weathering of the sandstone and siltstone on the abutments shows that there is a gradual breakdown of the rock under oxidation. The presence of water and reducing conditions have not appreciably weathered the rock in the flood plain.

Displacement occurs between the strata on the left abutment and the strata in the flood plain. This displacement could be caused either by faulting or by the lensing out of the bed for siltstone and shale present. If constant sedimentation is assumed to be present in this area, this displacement could indicate a fault zone.

Shallow residual soil occurs on each abutment. This soil has approximately 4.0 feet of red, hard, silty sand (SM). This soil is present from station 18+00 on the centerline of the dam to the top of the dam on the left abutment. On the right abutment, this type soil occurs from station 12+75 on the centerline of the dam to the top of the dam.

Cobbles, gravels, and boulders are present in the flood plain area. Interbedded within this coarse material is red, hard, silty sand (SM). This recent alluvium ranges in depth from 6.0 feet near the toes of both abutments to 25.0 feet in DH 34.

A low bench formed from cobbly alluvium occurs between station 16+30 and station 17+50 on the centerline of the dam.

To investigate the centerline of the dam, 9 holes were drilled into the rock. These are DH 31 through DH 39. Four test pits are present within 70 feet of the centerline of the dam in the flood plain area. These are TP 106 through TP 109. These test pits were dug to investigate the borrow area of the first proposed dam location.

Principal Spillway

The proposed pipe crosses the centerline of the dam at station 14+62 on the centerline of the dam and station 6+00 on the centerline of the pipe.

The flood plain in this area has 19.0 feet of cobbles, gravels and boulders (GM) present. The interstices are filled with red, hard, silty sand (SM).

Sandstone, siltstone and breccia underlie this coarse alluvium. The breccia in this rock is a sedimentary breccia which signifies that it is a conglomerate with angular pieces present.

To investigate this proposed pipe location, two drill holes were emplaced. These are DH 310 and DH 311.

Foundation

Foundation conditions are similar to those soil and bedrock conditions described on the centerline of the dam.

Other than the centerline of the dam and the centerline of the pipe, no further investigation was made of the foundation.

Emergency Spillway

The centerline of the emergency spillway crosses the centerline of the dam at station 10+64 on the centerline of the dam and station 4+32 on the centerline of the emergency spillway.

The emergency spillway cut is underlain by red sandstone and siltstone of the Hampshire formation. The unweathered sandstone is hard and indurated. The siltstone is moderately soft. The rock is fractured and jointed. The weathered zone extends approximately 8 feet into rock.

Residual, colluvial and terrace soil occurs in the proposed emergency spillway cut. The residual soil (Lehew series) is present in the upstream section and on the outer edge. This soil has approximately 6.0 feet of yellow brown to red silty sand (SM) below the shallow topsoil.

Colluvial soil occurs in the central and downstream part of the proposed emergency cut. This soil (Caylor series) has 8.0 feet of red brown, silty, gravelly sand (SM) present below shallow topsoil.

Terrace soil (Waynesboro series) occurs in part of the downstream cut of the proposed emergency spillway. This soil has 4.0 feet of red silty sand (SM) present below shallow topsoil. Below this SM material is present at least 3.0 feet of cobbles and gravels (GM).

To investigate the proposed 200-foot wide emergency spillway cut, 11 holes were drilled into rock. These are numbered DH 250 through DH 257 and DH 260 through DH 262. Also in the emergency spillway cut and back slope area, 25 holes were dug. These are numbered TP 117 through TP 125 and TP 201 through TP 218. Of these, AH 122 and AH 217 were dug with a hand auger. The remainder of the holes were dug with a backhoe.

Borrow Area

Five borrow areas were investigated. These have been designated as borrow areas A, B, C, D, and E.

Borrow Area A is located in the flood plain upstream from the dam site. This area has sandy cobbles, gravels and boulders (GM) present below a shallow topsoil. This material is class C fill material. At least 200,000 cubic yards of this material is available here.

Borrow Area B is located on the right abutment downstream from the emergency spillway cut. Residual, colluvial and terrace soils are present here. This soil is similar to the material described in the emergency spillway cut.

The soil series present are Lehigh series (residual), Caylor series (colluvial), and Waynesboro series (terrace). A low alluvial - colluvial terrace present under the foundation that was first investigated is included in Borrow Area B. An estimated 55,000 cubic yards of material is available in this borrow area. An estimated 43,000 cubic yards of this is suitable for core on cutoff material.

Borrow Area C is located on the left side of the stream valley approximately 500 feet upstream from the centerline of the dam. This borrow area is on a low terrace. The material here is sandy and cobbly old alluvium of the Waynesboro series. The brown red SM material ranges in

depth from 6.9 to 3.5 feet. Below this SM material is GM material of sandstone cobbles. This GM material surrounds Borrow Area C on the valley side. An estimated 8,000 cubic yards of SM material (for core) is available on this low terrace. In addition, GM material (for slopes) is available below the SM material. Borrow Area C was investigated by TP 101 through TP 105.

Borrow Area D is located on the left side of the stream valley 400 feet downstream from the centerline of the dam. This area is a small alluvial-colluvial terrace. It contains approximately 4.0 feet of brown red sandy silt (ML) below shallow topsoil. Test pits 129 through 131 were used to investigate this small borrow area. An estimated 5,000 cubic yards of ML material is available here.

Borrow Area E is located on the right side of the stream valley approximately 2,800 feet upstream from the centerline of the dam. This borrow area is located on a colluvial slope to a small stream valley. This small valley joins the main stream valley of Dry Run. Colluvial soil (Caylor series) is present. This soil has at least 6.0 feet of brown red silty cobbly sand (SM) present below shallow topsoil. Test pits 134 through 137 were used to investigate this borrow area. An estimated 30,000 yards of SM material is available here.

To investigate these borrow areas, 38 test pits were dug. These are numbered TP 101 through TP 138.

Brent, W. B., 1960, Geology and mineral resources of Rockingham County: Virginia Division of Mineral Resources Bull. 76, Map.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL SAMPLE LIST

SOIL AND FOUNDATION INVESTIGATIONS

U. S. Forest Service &
Town of Harrisonburg

Location Rockingham County, Va. Owner _____

Watershed Lower North River Sub-watershed Dry Run Site No. 22 B

Submitted by Mack, T. Date 3 19 6

Sent by Truck Government B/L No. _____
(carrier)

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Original to Salls Laboratory
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VI-7


VA 509-G

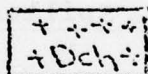
Sheet 7 of 8 Sheets

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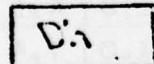
Mississippian

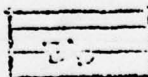
 Price Pecos light gray sandstone & quartzite

 + + + + + Chert

Chert light gray sandy shale

Devonian

 Hampshire red sandstone & shale

 + + + + + Triller gray sandy shale

Triller gray sandy shale

Geologic Map of the area surrounding Sites No. 22-A, 31-A, 35, 36, 37 & 32, Lower North River Watershed, Rockingham County, Virginia.

Scale 0 1 2 3 4 Miles

*Butts, Charles, 1933 Geologic Map of the Appalachian Valley of Virginia: Virginia Geol. Survey Bull. 42.

10-59

DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

State Virginia County Rockingham Watershed Lower N. River Subwatershed Dry Run
Site number 22 B Site group I Structure class b Investigated by J. M. Ma Geologist Date 3/66
(signature and title)

INTERPRETATIONS AND CONCLUSIONS

1. The centerline of the dam was moved 300 feet upstream to assure a less permeable condition in the abutments. The left abutment ^{on the downstream original site} was found to be permeable with water passing out into the valley of North River. It is to be assumed that entirely similar conditions are present in the right abutment. All surface examination of the rock shows that the rock in the right abutment is even more fractured and open than in the left abutment. In the right abutment weathered vertical fractures over a foot wide are present on the lower North River side of the cliff.
2. The placement of the centerline of the dam 300 feet upstream from the original centerline will entail a greater volume of rock that has to be removed from the emergency spillway cut. It is suggested that the width of this cut be cut down to perhaps 100 feet. The control section and a large extent of the floor of the cut will be on sandstone rock.
3. Weathered fractured rock occurs in each abutment. This open fracture zone depth in both abutments is over 33 feet deep. A better positive cutoff could be obtained by the removal of this weathered fractured rock.
4. Apparent displacement of beds occurs at approximately 18+50 on the centerline of the dam. This area may be investigated when the cutoff is cut for further fracturing due to possible faulting.
5. The cobbles, gravels and boulders (GM) in the foundation have a high bearing strength and a high permeability.
6. It is suggested to the Design Engineer that cutoff be taken in the flood plain to at least the top of rock.
7. The pipe will rest on a foundation of cobbles, gravels, and boulders. The difference in the shearing strength of this material and the shearing strength of the cutoff material is to be considered.
8. Some water is expected to pass through the rock below the zone of weathered and fractured rock as shown on the cross section on the centerline of the dam. Interception of this

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water can be accomplished by means of a rock toe. The alluvium in the flood plain appears to act as a good filter sheet. This is observed by the fact that Dry Run is "really dry." Only after a hard 2-inch rain was any water seen in the dry stream channel. The water from this drainage area passes through the cobbles in the flood plain.

An example of the permeability of this type material is shown by the dam at the Harrisonburg reservoir. Here, although Lower North River had no water in its channel, Harrisonburg was drawing 1-1/2 million gallons of water per day from water passing through the cobbles.

9. If there is interest in placing the pipe on rock, a location crossing the centerline of the dam at DH 37 could be considered or investigated.

10. Fine-grained borrow material for use in the core and cutoff is scarce. It is estimated that there is sufficient ML and SM material present to construct the dam. Borrow areas B and E are considered the prime sources of core material. It is suggested that these be used before clearing the smaller volume borrow areas for fine-grained material.

11. Sufficient coarse-grained material is present in Borrow Area A for use on the slopes of the dam.

12. Topsoil should be stockpiled and used for topdressing.

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Sheet 3 of 7

APPENDIX VII

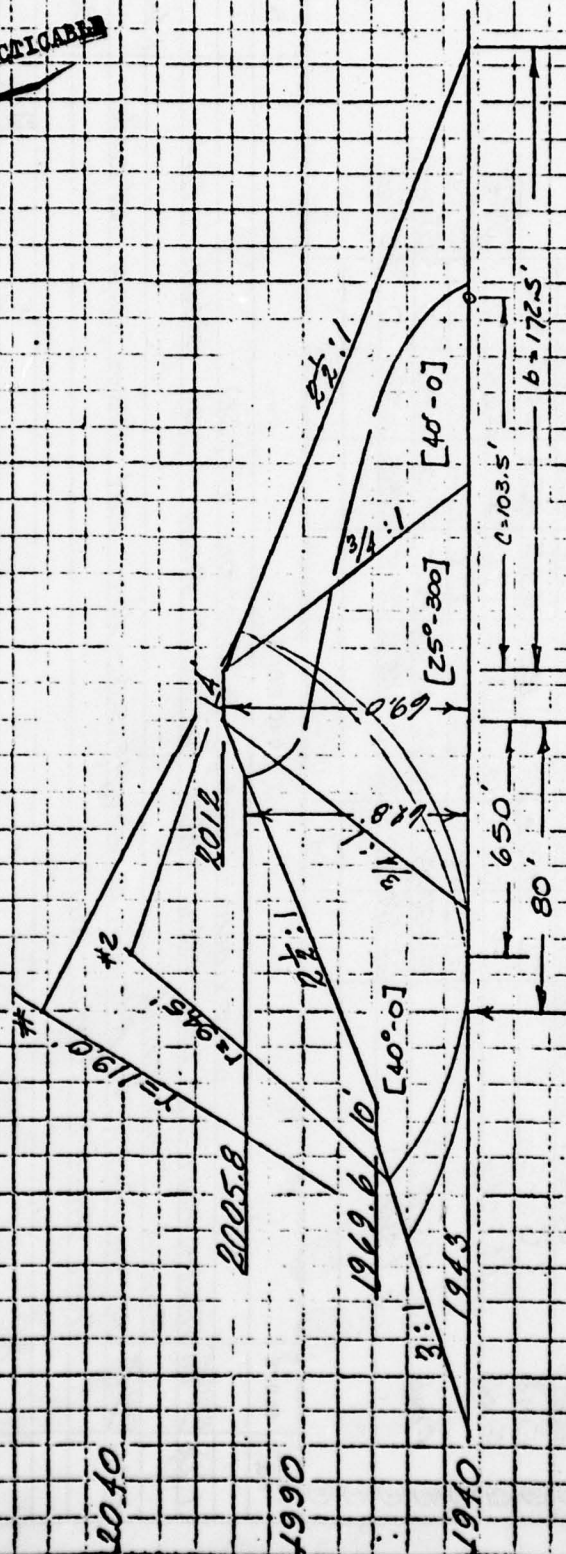
STABILITY ANALYSES

MATERIALS TESTING REPORT		U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE		SUMMARY - SLOPE STABILITY ANALYSIS				
PROJECT and STATE <i>LOWER North River Site # 225 VIRGINIA</i>					DATE <i>7-27-66</i>			
METHOD OF ANALYSIS <i>Swedish Circle</i>				ANALYZED AT <i>SW. LINCOLN, Neb.</i>	APPROVED BY			
SOURCE AND USE OF MATERIALS	CLASSIFICATION	ADOPTED DESIGN DATA					REMARKS	
		γ_d (pcf)	γ_m (pcf)	γ_{sub} (pcf)	θ (deg.)	$\tan \theta$		c (psf)
① Emb. (Shell) from site	GM	126.0	138.0	141.5	79.0	42.0	2.353	0
② Emb. (Core)	CL	108.4	122.5	128.0	65.5	25.0	0.466	300
③ Emb. (Shell)	GM	122.5	133.0	132.5	77.0	33.5	0.662	0
④	GM	122.5	133.0	132.5	77.0	22.0	0.554	0
⑤ Emb. (Shell)	GRGM	130.5	138.0	145.0	82.5	39.0	0.810	0
⑥	GRGM	130.5	138.0	145.0	82.5	38.5	0.795	0
⑦								
⑧								
CONDITIONS								
TRIAL NO.	SLOPE	F_s						
1 Up $2\frac{1}{2}:1$		Maximum Section @ Station 15+50						
		Full drawdown - 100' berm @ elev. 1969.6 - Arc cut from opp. shoulder thru						
2 Up $2\frac{1}{2}:1$		Zoned Emb. only						
		Full drawdown - 100' berm @ elev. 1969.6 - Arc cut from opp. shoulder thru Zoned Emb. only						
		1.44						
		1.53						
3 Up $2\frac{1}{2}:1$		Flood Plain Section Station 16+70						
		Full drawdown - 10' berm @ elev. 1969.6 - Arc cut from opp. slope thru						
		Zoned Emb. & 17' Found (35°-0)						
		1.35						
4 Up $2\frac{1}{2}:1$		Full drawdown - 10' berm @ elev. 1969.6 - Arc cut from same shldr. thru						
		Emb. (40°-0) & 17' Found (35°-0)						
		1.37						
* Up $2\frac{1}{2}:1$		* Infinite slope failure.						
		Emb. (40°-0) Rapid drawdown - (differential Flow Lines)						
		1.02						
On $2\frac{1}{2}:1$		Infinite slope - $F_s = \tan \theta = 0.839$						
		$\tan \theta = 0.400$						
		2.1						

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Maximum Section @ Station 15+7

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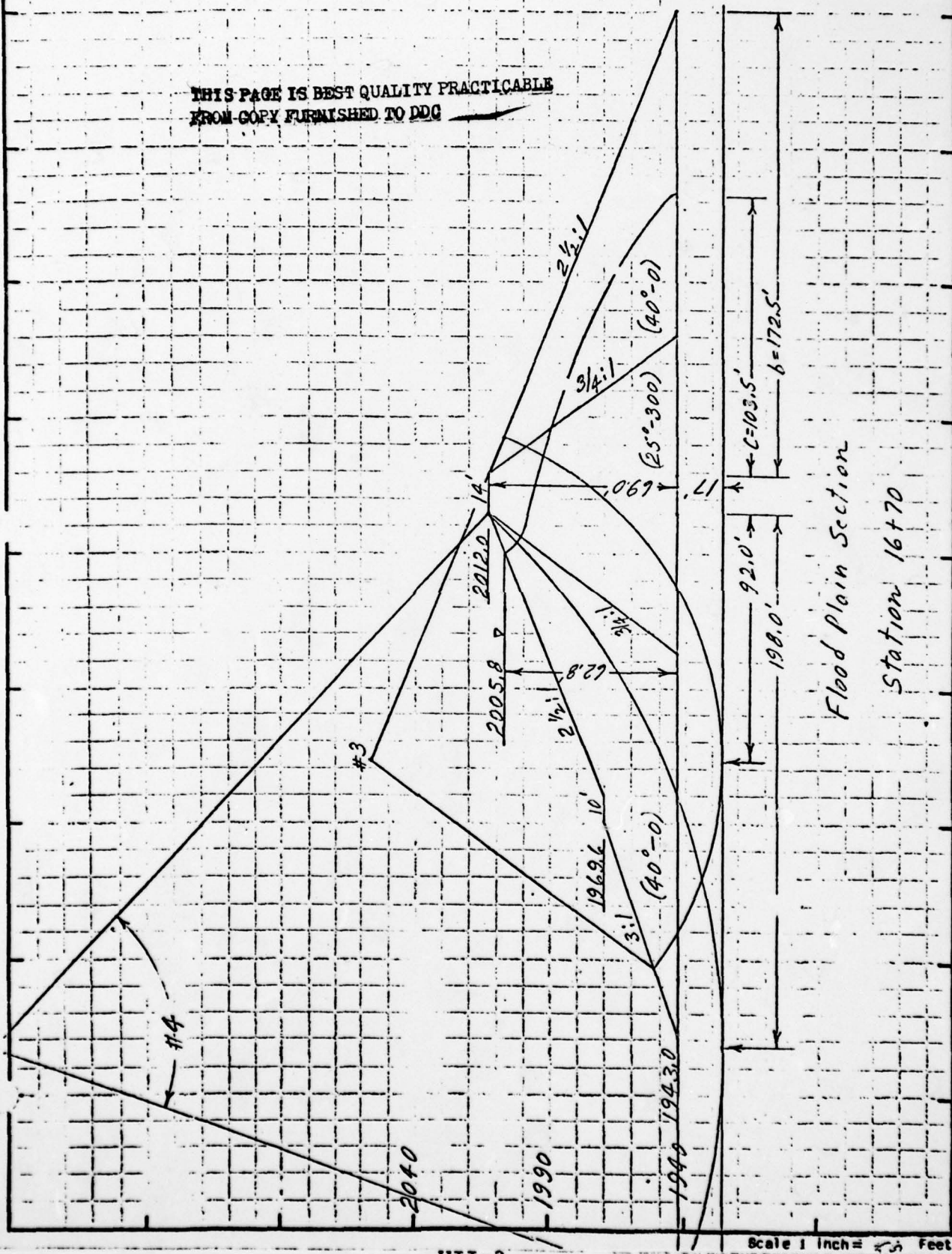
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Continuation of Sheet 1 of 3
Lower North River #22B
Virginia

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Flood Plain Section

Station 16+70

VII-3

Scale 1 inch = 5 Feet